SORENSEN
POWER SUPPLIES

Instruction Manual

MODEL "QR"

NOBATRON RANGERS

TRANSISTORIZED DC VARIABLE
VOLTAGE POWER SUPPLIES

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II. SPECIFICATIONS

Sorensen Model "QR" Nobatron Rangers are transistorized power supplies with a continuously variable, wide range output. They possess an extremely fast recovery time, stable regulation, and an unusual insensitivity to extreme input frequencies.

MODEL		QR36-4A	QR36-4AP	QR36-15A	QR75-2	QR150-1A
INPUT POWER A. C.	Voltage	Range 105 to 125V.				
	Freq.	50-400 cy	≠	≠	50-400 cy	50-400 cy
	Nominal	60 cy	60 cy	60 cy	60 cy	60 cy
	Current	3.2 A.		12 A.	3 A.	3.2 A.
OUTPUT POWER D. C.	Voltage	0-36 V.		0-36 V.	0-75 V.	0-150 V.
	Current	0-4 A.		0-15 A.	0-2 A.	0-1 A.
* % Regulation Line & Load Combined		±(.02% + 1 MV)		±(.02% + 2 MV)	50 MV	±(.02% + 4 MV)
Ripple @ 60 cy		0.5 MV. RMS		1 MV. RMS	5 MV. RMS	0.5 MV. RMS
Response Time (Micro sec.)		50		50	100	50
** AMBIENT TEMPERATURE 0° C (32° F) To 40° C (104° F)						
CABINET SIZE (in.)	Width	17	9	19 1/8	17	17
	Depth	14	15 3/4	13 1/2	14	14
	Height	5	11 5/8	11	5	5
Rack Height		5 1/4	Portable	10 1/2	5 1/4	5 1/4
Weight (Net)		45 lbs	45 lbs	95 lbs	45 lbs	48 lbs
Output Terminals		Binding post (front) & terminal board (rear)				
Meters		Voltmeter & Ammeter (Standard 2% Accuracy)				
Protective devices		Input & Output Fuse				

* Regulation accuracy guaranteed at the output terminals only, not at load input connections. (See Method of Sensing Page 6).

** Regulation not guaranteed with ambient changes. (15° C. to 35° C. output change for fixed line and load 0.03%/° C. typical).

≠ Forced air cooling. Consult factory for other than 60 cy. operation.

INPUT FREQUENCY

"QR" NOBATRON RANGERS may be operated over an input range from 50 to 400 cyps., however, all specifications are only guaranteed at the nominal input frequency of 60 cps. The ripple voltage will increase as the frequency varies from 60 cps., becoming higher at the lower frequency extreme. The regulation accuracy and output voltage range are also affected by the input frequency, their specifications are only guaranteed at 60 cps.
NOTE: QR36-15A is designed for 60 cy. operation only.

RESPONSE TIME

When an abrupt change occurs in the input voltage or output load, an instantaneous change in output voltage occurs. This instantaneous change is quickly suppressed by the regulating action of the Nobatron. Recovery time is a measure of how fast this change is suppressed. It is defined as the time necessary for the output voltage to affect a 63% recovery from the maximum deviated value, based upon a 10% line voltage change, or a 50% step change in load.

TYPICAL OVERSHOOT QR36-4A

	36V	30V	20V	15V	10V	2V	0V
1. Starting	0	0	0	0	1.6V	3V	6V
2. Turn off	0	0	0	0	0	0	0

IR Drop between front and rear output terminals is approximately 95 MV.

SHORT-TERM DRIFT

Short-term drift after 15 minute warm up. 05% typical.

III. INSTALLATION AND OPERATION

RACK MOUNTING OR BENCH OPERATION

These instruments when originally purchased may be supplied self-contained for bench top operation or equipped for mounting in a standard 19" relay rack. In the event it is later desired to rack mount a self-contained unit or vice versa, this may be accomplished without difficulty. The user should contact our local representative or the Sorensen Service Department for the necessary parts and instructions for conversion.

Terminals & Controls

1. Input Power Connections
   The input power is applied by means of a line cord utilizing a 120 volt polarized three prong plug. Since the third prong of this plug is connected to the chassis, connection of the line cord to the appropriate receptacle automatically grounds the equipment. If the user does not have three prong outlets available, he should use an adapter. The user should make sure that the extra wire (coded green) coming out from the adapter is solidly grounded to the power line wiring system, preferably soldered. The aforementioned should be carried out for safety reasons.

2. Output Power Connections
   The DC output is available at the two binding posts located on the front panel or at the terminal board located at the rear of the instrument. Ground terminals are also provided for safety purposes. Since the output is floating, either output terminal may be grounded.

3. On-Off AC Power Switch
   The AC Power On-Off switch is located on the front panel.

4. DC Voltage Control Knobs
   a. A coarse DC voltage control knob which is provided on the front panel actuates a variable auto-transformer. This transformer gives full output voltage adjustment from zero to the rated DC output.

   b. A fine DC voltage control knob allows for more minute adjustment of the output voltage.

Fuses and Protective Devices

1. The AC Protective Fuse (F1) protects the internal variable auto transformer (voltage control) and other components from injury due to internal short circuits, etc. This fuse should normally never need replacing.
2. The DC output overcurrent protective fuse F2 protects the instrument against external overload or short circuits.

CAUTION: Always replace fuses with an exactly rated duplicate. An oversize fuse may cause breakdown of components.

STARTING RELAY

In some models a starting relay K1 is used to prevent the output from overshooting at turn on. To accomplish this, a circuit in the main power supply is switched by K1, after a specified time delay. This allows the reference (negative) power supply to reach operating output voltage, before the main power supply does.

In Model QR75-2, K1 switches the primary circuit of the input transformer. In Model QR36-15A, K1 switches a resistor R2 in series with the input to the main power supply.

LOCAL SENSING

For specified regulation accuracy, load wires and sensing leads both must be connected either at the front panel or at the rear output terminals.

When taking power from the front panel terminals:

1. There must not be any links or jumpers between the rear remote sensing terminals and the rear output terminals
2. There must be links (tightly secured) connecting the front remote sensing terminals and the front output terminals.

When taking power from the rear output terminals:

1. The sensing leads must be open at the front panel.
2. There must be jumpers (tightly secured) connecting the rear remote sensing terminals and the rear output terminals.

REMOTE SENSING

1. There must be no links or jumpers connecting remote sensing terminals and output terminals front or rear.

2. Connect load wires to either the front or rear output terminals.
3. If load wires are attached to the front output terminals, connect two sensing leads from front remote sensing terminals directly to the load. If load wires are attached to the rear output terminals, connect two sensing leads from the rear remote sensing terminals directly to the load.

NOTE: Load connections and sensing leads must always be attached at the same position, ie. all four wires at the front panel or all four wires at the rear terminals. Unless this is done, poor regulation will result.

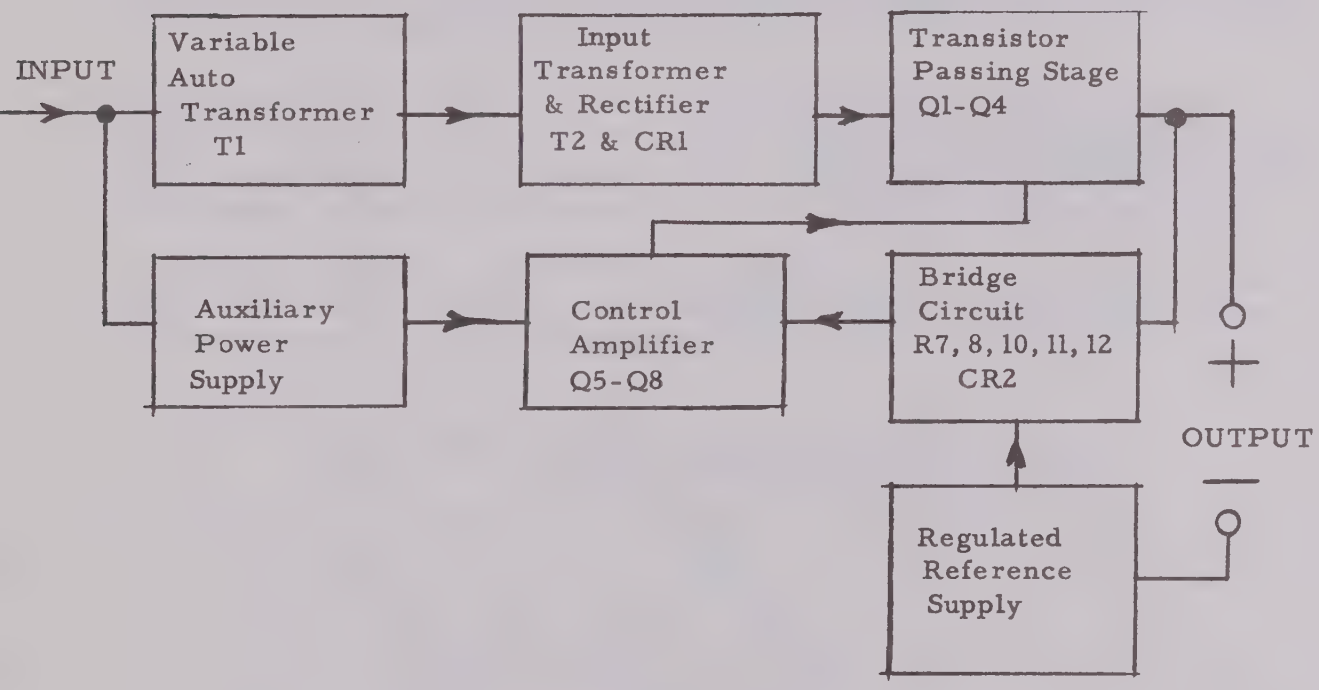
CAUTION: Make sure that sensing link and sensing lead connections are kept tightly secured at all times of operation of the Nobatron. This is to protect transistors in the amplifier

IR drop in remote sensing leads must be less than 0.40 volts for proper operation.

IV. PRINCIPLE OF OPERATION

The "QR" Nobatron Ranger is a regulated DC power supply, employing semiconductors throughout. The operation of the "QR" Nobatron Rangers can best be understood by referring to the block diagrams shown below and to the schematic diagram furnished with this manual. Several different circuits are used.

BLOCK DIAGRAM MODEL QR75-2



PRINCIPLE OF OPERATION MODEL QR75-2

Input Power is applied to the variable auto transformer (T1) which sets it to the desired voltage level.

This new voltage is then applied to the Input Transformer (T2). The output of this transformer is rectified (CR1) and filtered (C1). The negative return of this output goes directly to the negative output of the unit. The regulating action of this unit is controlled by transistors Q1, Q2, Q3, and Q4 which are connected between the positive output of the rectifier and the positive output of the unit. These transistors serve as a variable impedance to control the output voltage similar to the action of a passing tube in a tube type regulated supply. This impedance is varied by the transistor amplifier consisting of Q5-Q8 which controls the base currents of the passing transistors. The first amplifier stage, Q8 is controlled by a bridge circuit consisting of R6, R7, R8, R10, R11, R12 and CR2. CR2 is a reference diode which holds the base of Q8 at a fixed potential above the negative output terminal.

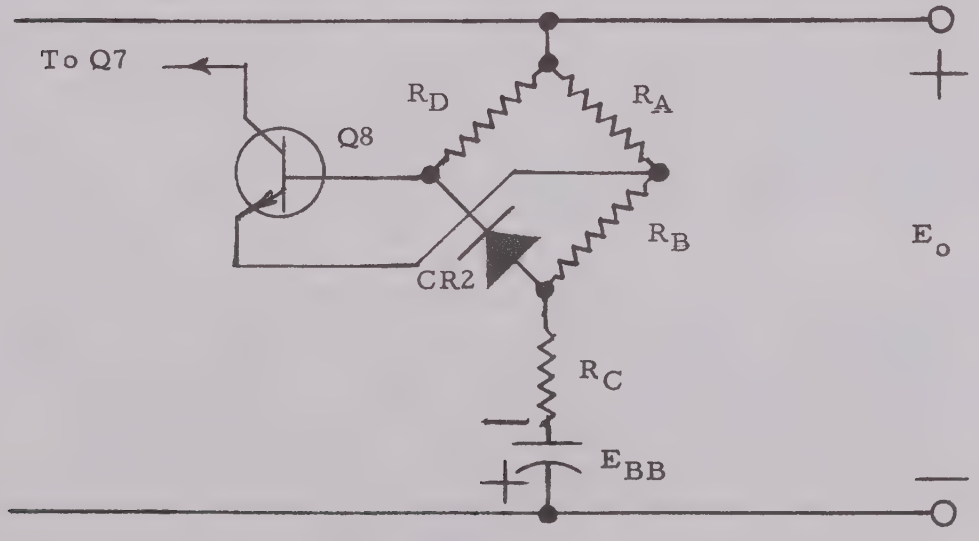
Any variation in the output voltage E_o, due either to line or load changes, varies the voltage drop across R_B. This in turn changes the output of the bridge and thus creates a signal for amplifier Q8 to act upon. For example, if the output tends to rise, the voltage across R_B increases. This decreases the input to Q8 base - emitter, reducing the collector current of Q8 and through all subsequent amplifiers (Q7, Q6, and Q5). A reduced base current into Q1-Q4 increases their impedance, thus reducing the output to its proper voltage level.

The voltage E_{BB} is the output voltage of a regulated reference supply. This reference supply operates similarly to the main regulator except that the input stage (Q12 and Q13) is a differential amplifier. Voltage E_{BB} serves as a battery in the sensing circuit of the supply, providing a bucking voltage in this circuit. This allows the output voltage to be reduced to zero.

The output voltage is varied by changing the value of R14 and R13, the "Fine" and "Coarse" controls. In order to reduce the dissipation of the passing transistors Q1-Q4, potentiometer R13 is ganged to the variable auto-transformer. Therefore, as the output voltage is made to increase, the output of T1 is also increased.

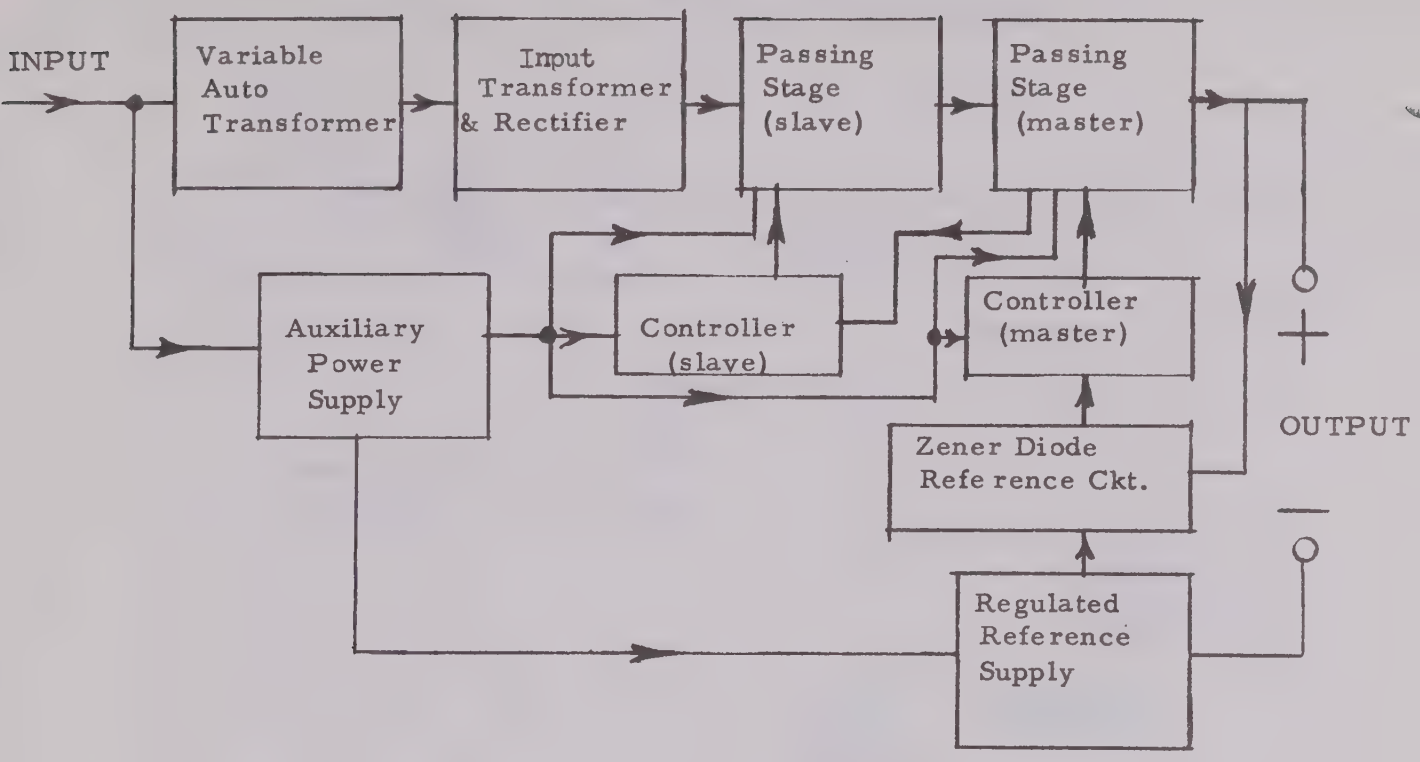
An auxiliary supply (C5, C6, C7 output) supplies negative bias to the passing transistors and to the drivers and power amplifiers of the control circuits. This bias prevents thermal "runaway" at high ambients.

BASIC REFERENCE AND COMPARISON CIRCUIT



R_A = R7, R8, RT1, R10
R_B = R11, R12
R_C = R13, R14
E_{BB} = Voltage across C8
CR2 = Reference diode

BLOCK DIAGRAM, MODELS QR36-4A, QR36-4AP, QR36-15A, QR150-1A



Principle of Operation, Models QR36-4A, QR36-4AP, QR36-15A, QR150-1A

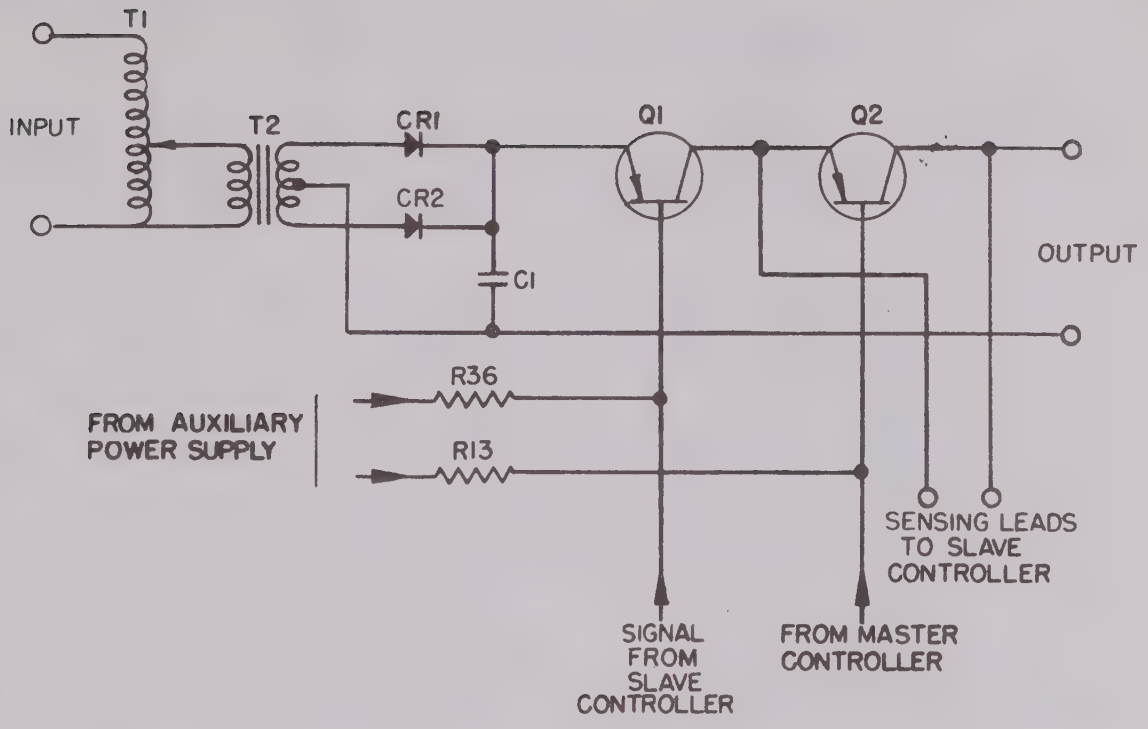
Refer to appropriate schematic diagram included as part of this manual. The component symbols included in this description apply to the symbols used in the typical sectional schematics below. They do not necessarily apply to the symbols on the individual schematic diagrams. Input power is applied to the variable auto transformer (T1) which sets the desired voltage level. This new voltage is then applied to the input transformer (T2). The output of this transformer is rectified (CR1), (CR2), and filtered (C1). The negative return of this output goes directly to the negative output of the unit.

The regulating action of the instrument is controlled by the passing transistors (Q1, Q2), which are connected between the positive output of the rectifier and the positive output of the supply. These transistors serve as a variable impedance to control the output voltage, in a manner similar to the action of a passing tube stage in a tube type regulated supply. This impedance is varied by the transistor amplifiers.

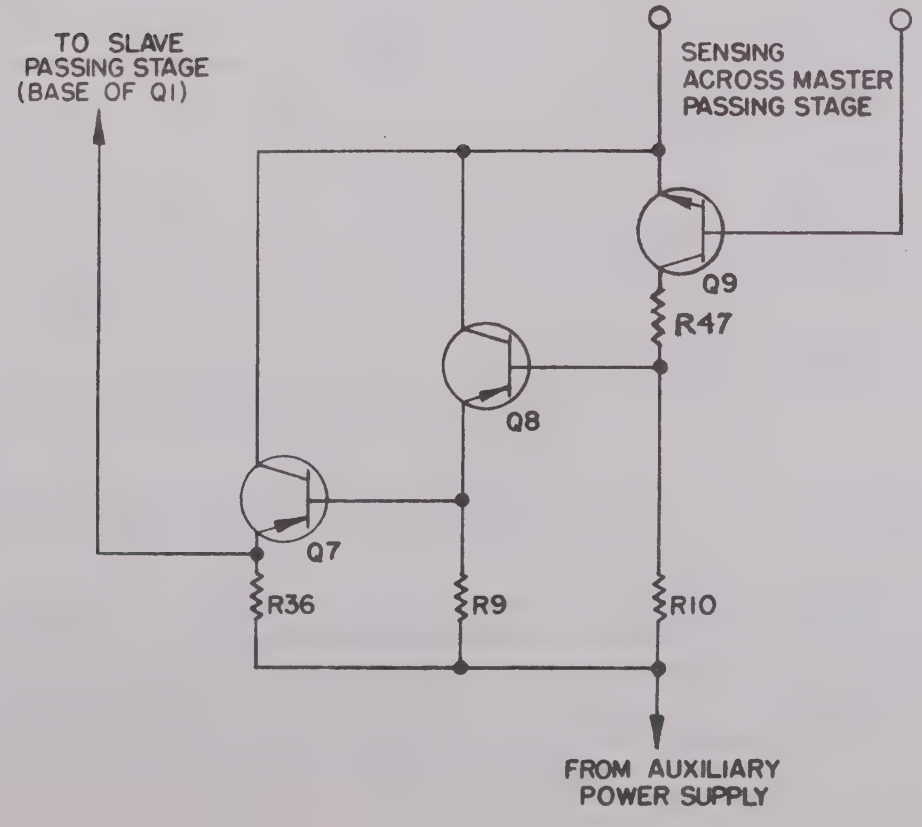
The main control amplifier (Q10-Q15), and reference diode (CR4) control the impedance of the master passing stage.

A current amplifier (Q7, Q8, Q9) sensing across the master passing stage controls the impedance of the "slave" stage. The number of slave stages depends on the output voltage of the "Q ranger".

TYPICAL POWER SECTION



TYPICAL SLAVE CONTROLLER



The control amplifiers vary the base currents in the passing stages, adjusting them to keep the output voltage constant.

THE MAIN CONTROL AMPLIFIER

A bridge circuit consisting of R21-R25 and CR4, sensing in the output of the unit controls the first differential amplifier stage (Q14, Q15). The base of Q14 varies with the output. Since the emitters of Q14 and Q15 are connected, any variation in the output voltage changes the base emitter voltage of both Q14 & Q15.

If the output tries to rise, due to line or load change, the base of Q14 tends to rise causing more current to flow in this transistor. The emitters of Q14 and Q15 go to a higher potential. Since the base of Q15 is held constant, by reference diode CR4, this transistor tends to "cut off". Less current will flow in Q15 and collector resistor R20. Collector of Q15 is now at a higher potential and therefore the base of Q13 is also at a higher potential. This causes more current to flow in Q13 and tends to raise the voltage at Q12 and Q13 emitters. Since the current in Q14 tends to rise, the current in collector resistor R18 also tends to rise. This brings the collector of Q14 and the base of Q12 to a lower potential. Since the base potential went down and the emitter potential went up Q12 tends to "cut off", and there is less current available to bases of Q10 and Q11. Less current flows in Q10 and therefore less positive bias is applied to the base of the passing transistors in the "master" passing stage (Q2, Q4, Q6). The impedance of these transistors goes up thus restoring the output voltage.

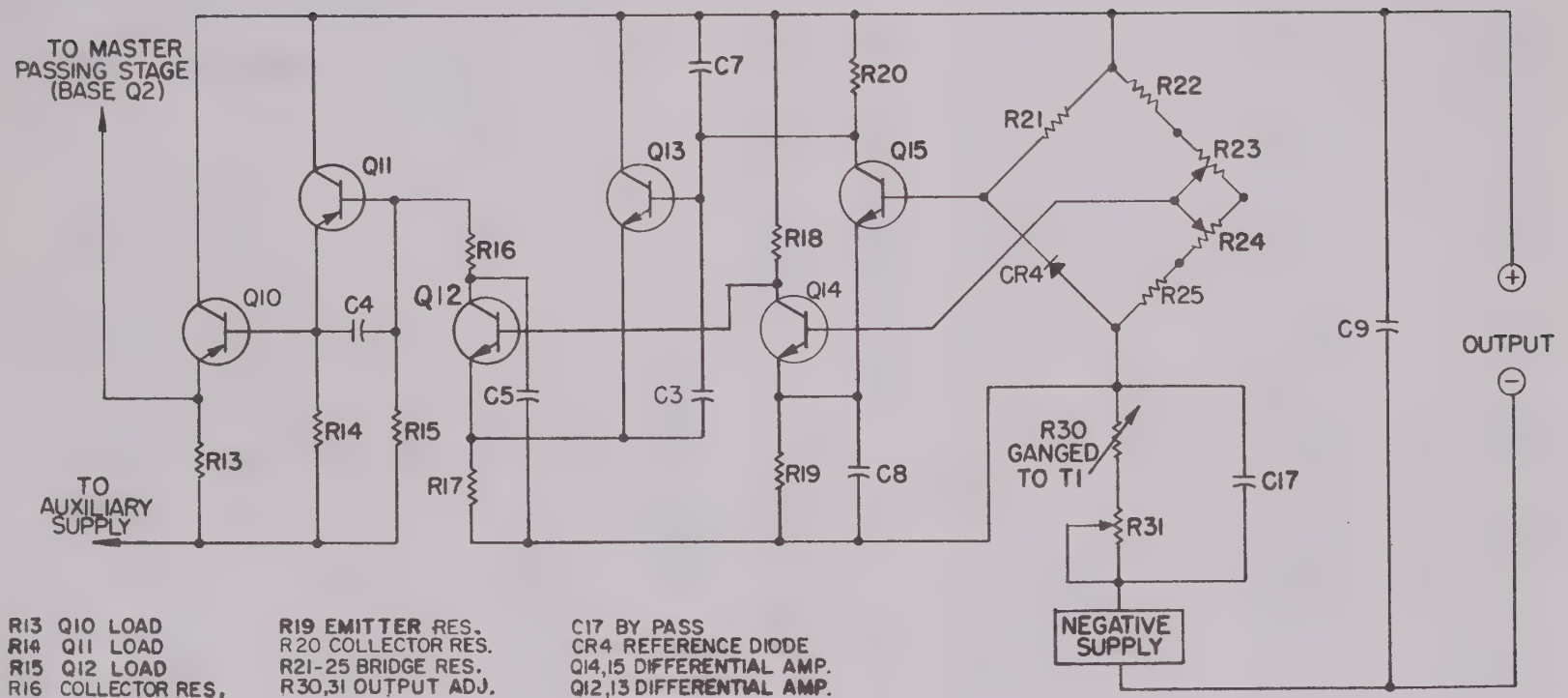
If the output tends to fall, due to line or load change, the base of Q14 tends to fall and less current flows in this transistor and its collector resistor R18. The potential at the collector of Q14 and the base of Q12 tends to rise. The emitters of Q14 and Q15 go to a lower potential and since the base of Q15 is held constant, by the reference diode CR4, more current flows in Q15 and its collector resistor R20. The collector of Q15 and the base of Q13 tend to go down causing less current to flow in Q13. The emitters of Q12 and Q13 are now at a lower potential, and since the base of Q12 went up, more current flows in this transistor. This causes more current to flow in the base circuits of Q10 and Q11. More current now flows in Q10 applying more positive bias to the base of the passing transistors, in the "master" passing stage (Q2, Q4, Q6). The impedance of this stage is thus lowered, restoring the output voltage.

The differential amplifier developes a regulated voltage across R22-R25. This voltage maintains constant current through the sensing circuit, with R30, R31. The value of R30, R31 adjusts the output voltage.

C17 presents a low impedance to the ripple current, and a low impedance path for the AC signal to the main amplifier.

R8 and Q22 form a protective circuit against short circuit damage to the main control amplifier. Normally Q22 is biased to near saturation, and offers a low impedance path to current in the low side of the amplifier. When a short occurs the bias of Q22 changes to "cut off" this transistor, in effect opening the low side of the amplifier making it inoperative. (Model QR36-15A Uses a zener diode CR11 to open the amplifier circuit)

TYPICAL MAIN CONTROL CIRCUIT



R13 Q10 LOAD
R14 Q11 LOAD
R15 Q12 LOAD
R16 COLLECTOR RES.
R17 EMITTER RES.
R18 COLLECTOR RES.

R19 EMITTER RES.
R20 COLLECTOR RES.
R21-25 BRIDGE RES.
R30,31 OUTPUT ADJ.
C3,4,5,7,8 STABILIZING CAP.
C9 OUTPUT FILTER

C17 BY PASS
CR4 REFERENCE DIODE
Q14,15 DIFFERENTIAL AMP.
Q12,13 DIFFERENTIAL AMP.
Q10 DRIVER
Q11 AMPLIFIER

CONTROL OF THE "SLAVE" STAGE

If the output tends to rise, due to line or load change, the emitter of Q9 goes up with respect to its base and it tends to "cut off". This tends to reduce the current through Q8 and Q7 to the base of the "slave" passing stage (Q1, Q3, Q5). The impedance of this stage tends to rise thus helping to restore the output voltage.

If the output tends to fall, due to line or load changes, the emitter of Q9 goes down with respect to its base. The current through Q9 increases, thus increasing the current through Q8 and Q7 to the base of the "slave" passing stage. The impedance of this stage tends to reduce thus helping to restore the output.

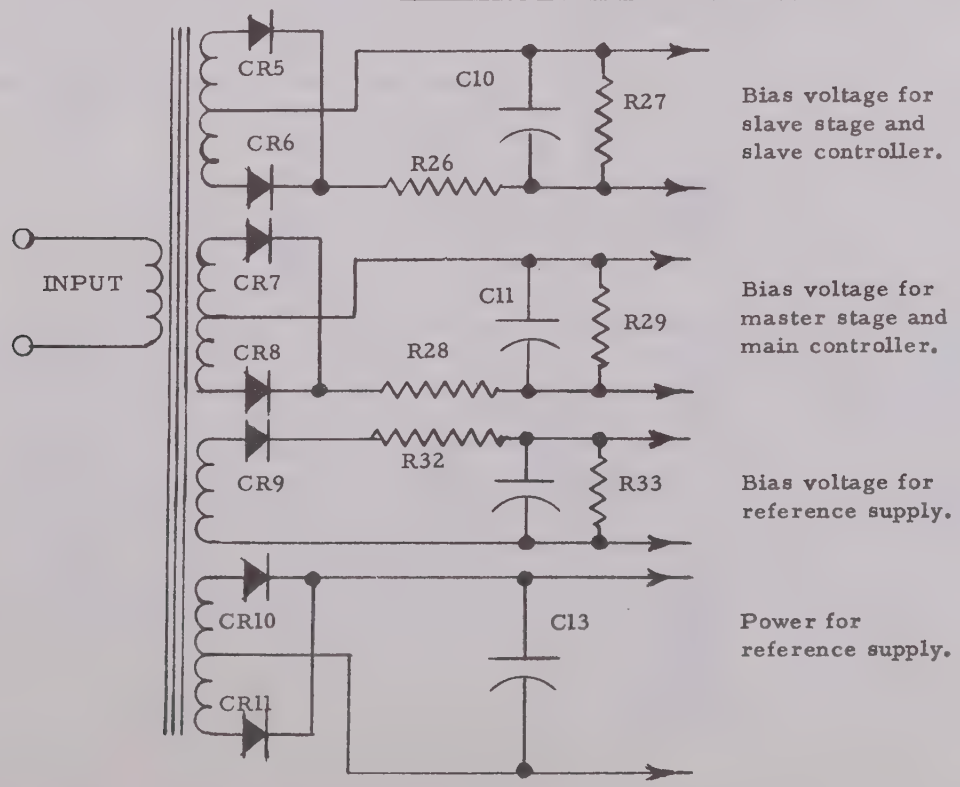
REFERENCE (NEGATIVE) SUPPLY

The voltage across C16 is the output voltage of a small regulated reference supply. The operation of this supply is similar to that of the main control amplifier. The voltage across C8 serves as a battery in the sensing circuit of the supply, providing a bucking voltage in this circuit. This allows the output to be reduced to zero.

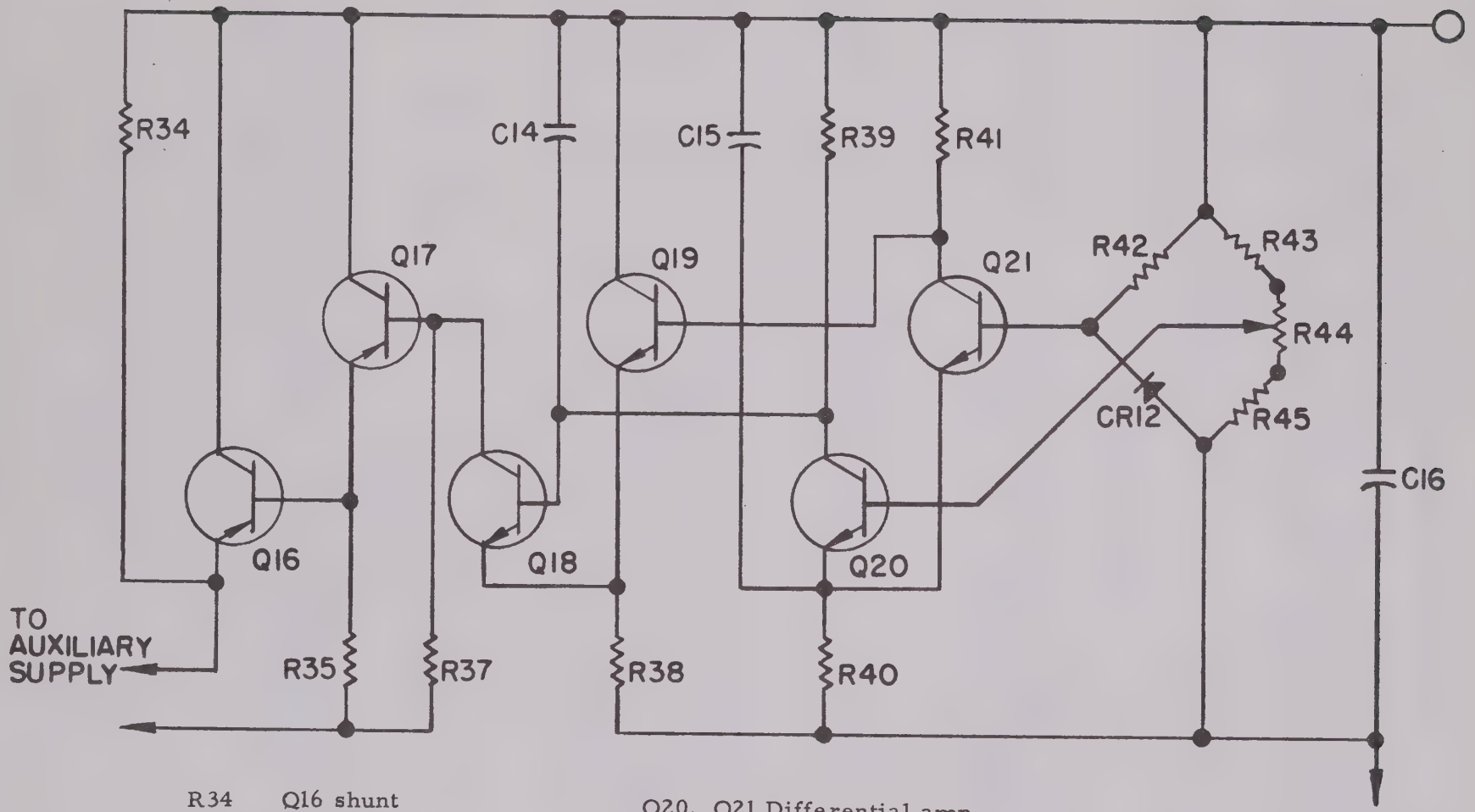
THE AUXILIARY SUPPLY

An auxiliary supply (C10, C11, and C12 output) supplies negative bias to the passing transistors, drivers and power amplifiers of the control circuits. This bias prevents thermal "run away" at high ambients.

TYPICAL AUXILIARY SUPPLY



TYPICAL REFERENCE SUPPLY
(NEGATIVE SUPPLY)



R34	Q16 shunt	Q20, Q21	Differential amp.
R35	Q17 load	Q18, Q19	Differential amp.
R37	Q18 load	Q17	Current amp.
R38	Q19 load	Q16	Passing Stage
R39, 41	Collector resistors	C14, C15	Stabilizing capacitor
R40	Emitter resistor	C16	Reference supply filter
R42-45	Bridge resistors	CR12	Reference diode

V. MAINTENANCE AND REPAIR

During normal life this instrument requires no maintenance other than the care afforded similar equipment. It is suggested that the excessive dust, and any other foreign matter be removed periodically, exercising care to prevent damage to the instrument by cleaning tools or excessively strong air blasts.

Special attention should be given to keeping any air filter clean, to insure a free passage of air.

SPARE PARTS

All Components used in these instruments are of good commercial grade and can be expected to give a reasonably long period of trouble free service. As the age of the instrument increases, some components are likely to deteriorate. We suggest that the items marked with asterisks, on the Replacement Parts List, be kept on hand.

In the event it becomes necessary to replace any part, we strongly suggest that the replacement parts be of the same value as the original. Substitute parts should not be used unless we assure you that the substitute part will not impair the performance of the instrument.

If it becomes necessary to replace a passing stage transistor in this instrument use only transistors purchased from the factory. At the present time parameter tolerances on germanium transistors are not held close enough to guarantee interchangeability. Passing stage transistors used in this equipment, are especially processed and selected to hold their parameters to close tolerance. Commercially available transistors may degrade the temperature stability or the performance of the instrument.

CAUTION

KEEP THE SENSING LINKS TIGHT AT ALL TIMES.

REPAIR

Only qualified personnel understanding transistorized regulator circuitry should attempt the repair of this unit if damage should occur. Major servicing should be done only by the factory or one of its representatives. (See Trouble Shooting Chart next page.)

TROUBLE SHOOTING CHART

MODEL QR75-2

SYMPTOM	PROBABLE CAUSE	PROCEDURE FOR REPAIR
1. No output (With volt adjust set at max. clock wise pos.).	Fuse blown	Replace
	K1 defective	Check and replace
2. Low output (with volt adjust set at max. clockwise pos.)	CR2 shorted	Check and replace
	Q6, Q7 shorted	Check and replace
	Low Zener Voltage	Check and replace
	C1 voltage low	Check T1, T2, T3 and ganged ass'y.
3. High output (With volt adjust set at max. clockwise pos.)	Voltage at C1 high	Check T1, T2, T3 and ganged ass'y.
	Passing transistor shorted	Remove driver transistor from control amplifier. If output doesn't fall trouble is probably in passing stage.
4. High output range	Reference supply not operating properly	Check transistors and reference diode.
	Ganged ass'y loose or set improperly	See adjustment procedure page 19 .
5. Poor regulation	Low gain in one of the amplifiers	Check all semi-conductors.
	Reference supply defective	Check.
	Auxiliary supply defective	Check.

MODEL QR36-4A, QR36-4AP, QR36-15A and QR150-1A

1. No output (With volt adjust set at max. clockwise pos.)	Fuse blown	Replace
	K1, K2 defective	Check and replace
2. Low output(with volt adjust set at max. clockwise pos.)	Q13, Q14 shorted.	Replace
	Low zener voltage.	Chcek zener and replace
	Reference supply output out of tolerance	Check adjustment procedure page 18 .
	C1 voltage low	Check T1, T2, T3, and ganged ass'y.

SYMPTOM	PROBABLE CAUSE	PROCEDURE FOR REPAIR
3. Incorrect output range	Reference supply not operating properly. Ganged ass'y loose or set improperly	Check transistors and reference diode. See adjustment procedure page 18.
4. High output (with volt adjust set at max. clockwise pos.)	Voltage at C1 high	Check T1, T2, T3, and ganged ass'y.
		Remove drivers from control amplifiers.
	Passing transistor shorted.	If output does't fall trouble is probably in passing stage.
		If output does fall, trouble is probably in
	Q10, Q11, Q12, shorted Q15 shorted.	one of the amplifiers. Check and replace.
	CR 4 open	Check and replace
5. Poor regulation	Low gain in one of the amplifiers.	Check transistors and reference diode.
	Reference supply defective.	Check
	Q7, Q8, Q9 shorted	Check and replace
	Auxiliary supply defective.	Check
6. High output ripple	C1, C9, C13, C16, C17 defective.	Check and replace
	CR1 or CR2 defective	Check and replace
	Low gain, defective transistor	
	Loose connection	
	Part of rectifier transformer secondary open	

WHEN REPLACING TRANSISTORS AND REFERENCE DIODES REFER TO PAGE 15, AND ADJUSTMENT PROCEDURE BELOW.

NOTE; Component symbols used in this chart refer to symbols in typical sectional schematics under principle of operation page 9. They do not necessarily correspond to symbols on individual schematic diagrams.

ADJUSTMENT PROCEDURES

Model QR36-4A, QR36-4AP

A. Initial Settings

1. Coupling between variable auto transformer (T1) and pot. (R30 loose).
2. T1 (front panel coarse control) set to minimum.
3. R30 set completely counter clockwise (zero resistance).
4. R31 set to minimum. (Fine adjust).
5. R23, R24, R44 set to approx. center of range.

B. Procedure

1. Connect a DC voltmeter 10V. (WESTON TYPE 931 or equivalent) and an AC Voltmeter (3MV HEWLETT-PACKARD TYPE 400D or equivalent) from negative side of C17 to negative side of voltmeter M2.

2. Adjust R44 for voltmeter reading of 6.0-6.1 VDC.

3. Vary input from 105-125 volts. Reading should not vary more than 1 mv dc approx. Ripple should be approx. 50 microvolts AC.

4. Model QR36-4A: Connect DC voltmeter across C1, input at 115V, rotate coarse adjust clockwise until meter indicates 20-21VDC.

   Model QR36-4AP: Connect DC Voltmeter across R46 input at 115V, rotate coarse adjust clockwise until meter indicates 20-21 VDC. R46 is located at the left side of the unit.

5. Turn unit off, lock coupling between T1 and R30.

6. Turn unit on and recheck item 4.

7. With meter scale at 50 volts, rotate coarse control for maximum output.

8. Adjust R24 to give 35.7 - 36.3V output.

9. Rotate coarse control to minimum.

10. Set DC meter to 2V range and adjust R23 so that voltmeter reads approx. 1 or 2 divisions below zero.

11. Repeat steps 7 and 8.

12. Repeat steps 9, 10 and 11 as many times as necessary to accomplish goal of minimum reading of approximately -.02V and maximum reading of 36 ± 0.3V.

13. With coarse control set for minimum output volts, rotate fine control and determine its range of adjustment. This should be approximately 0.8 V.

Model QR 75-2

A. Initial settings

1. Set tap on R1 to center.

2. Coupling between variable auto transformer loose.

3. T1 (front panel coarse control) set to minimum.

4. R13 set completely counter clockwise (zero resistance).

5. R14 set to minimum.

6. R10, R11, R27 set to approx. center of range.

B. Procedure

1. With DC voltmeter 10-20V. (WESTON Type 931 or equivalent) and an AC voltmeter 3 mv. (HEWLETT-PACKARD Type 400 D or equivalent) across C8, turn unit on.

2. Adjust R27 for voltmeter reading of 9.1 - 9.2 VDC.

3. Vary input from 105-125 volts. Reading should not vary more than 30 mv. DC approx. Ripple should be approx. 1 mv. AC.

4. With DC voltmeter (50V) across C1 and input at 115 V, rotate variable auto transformer T1 clockwise until voltmeter reads 20-21 VDC.

5. Turn unit off and lock coupling between T1 and R13.

6. Turn unit on and recheck item 4.

7. Change meter scale to 100V and put meter across output terminals. Rotate coarse control for maximum output.

8. Adjust R11 to give 74.5 - 75.5 V output.

9. Rotate coarse control to minimum.

10. Set DC meter to 2 V range and adjust R10 so that voltmeter reads approx. 1 or 2 divisions below zero.

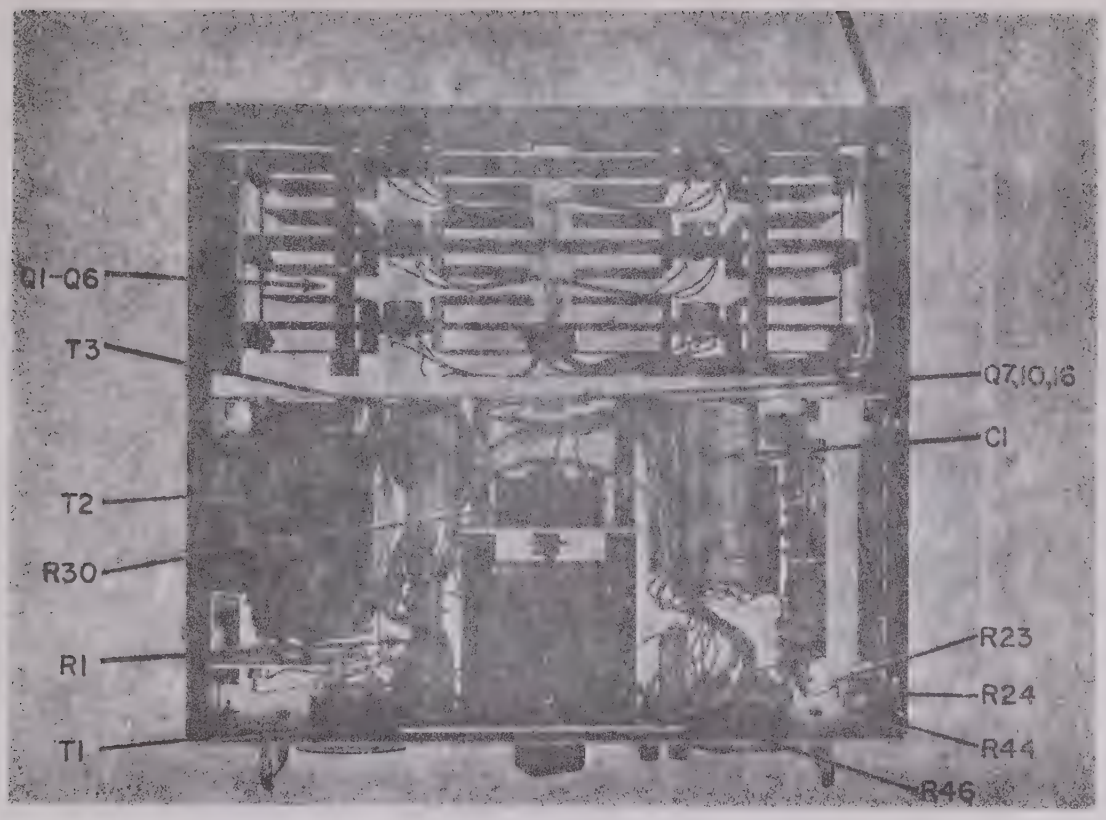
11. Repeat steps 7 and 8.

12. Repeat steps 9, 10 and 11 as many times as necessary to accomplish goal of minimum reading of approximately -.02V and maximum reading of 75 $\pm$ .5 V.

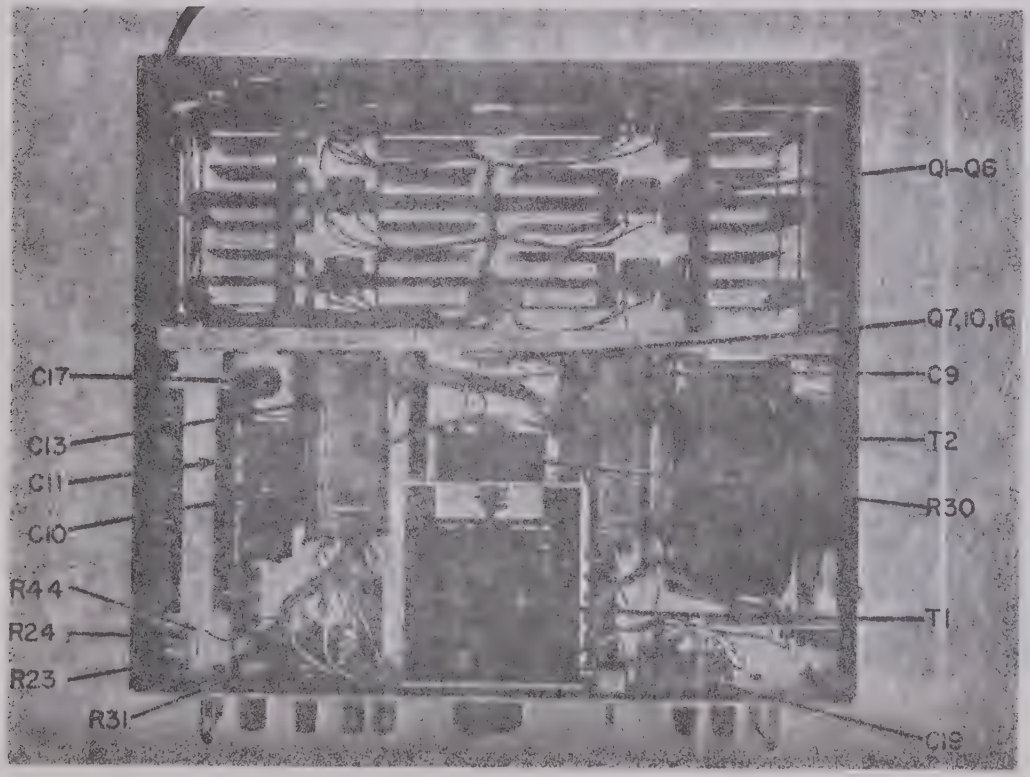
13. With coarse control set for minimum output volts, rotate fine control and determine its range of adjustment, This should be approx. 0.9 V.

14. With output adjust set at 75V, adjust R33 (load compensation) so that variation of output with load is less than 10 millivolts.

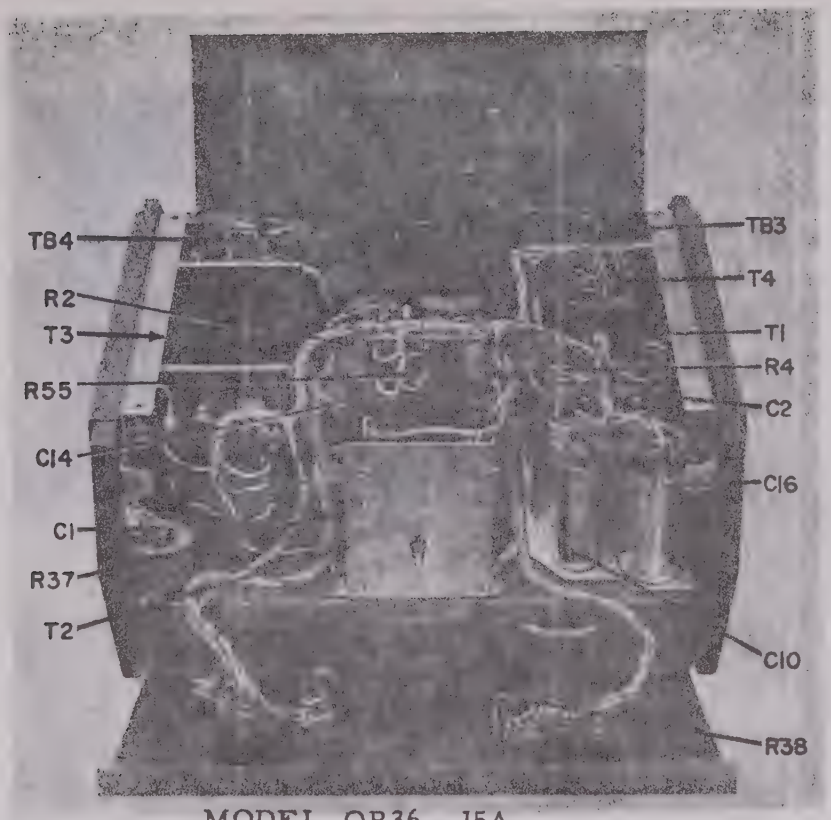
NOTES



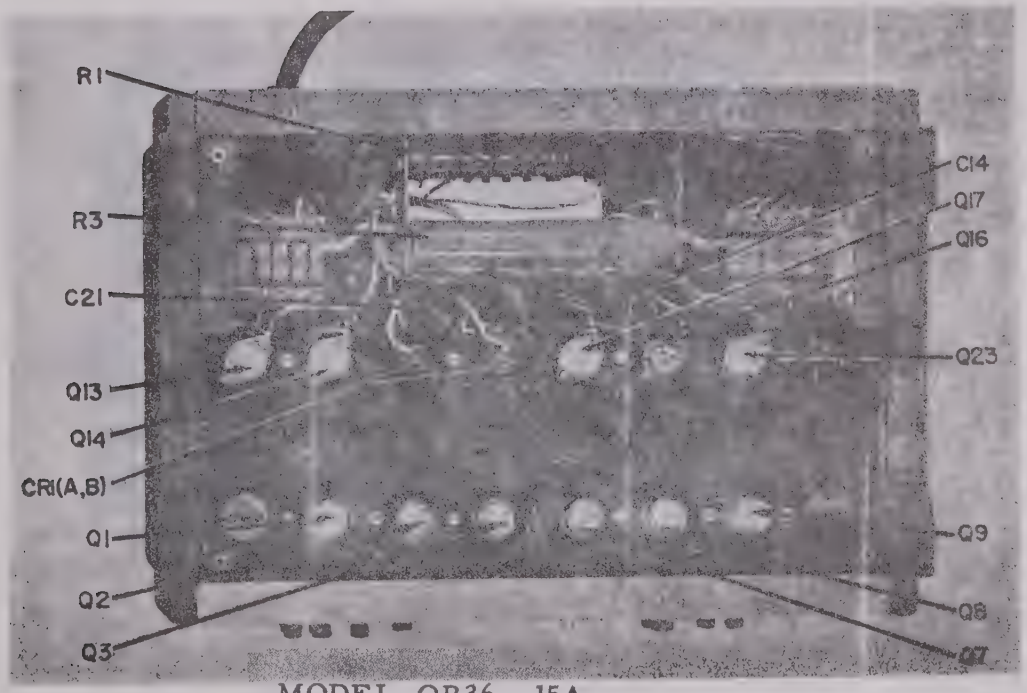
MODEL QR36-4A TOP VIEW
Note: MODEL QR75-2 is similar



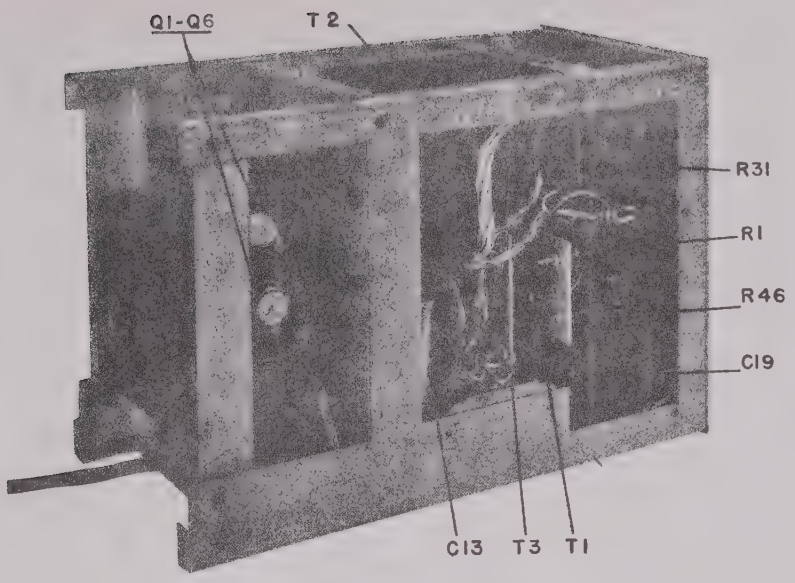
MODEL QR36-4A BOTTOM VIEW
Note: MODEL QR75-2 is similar



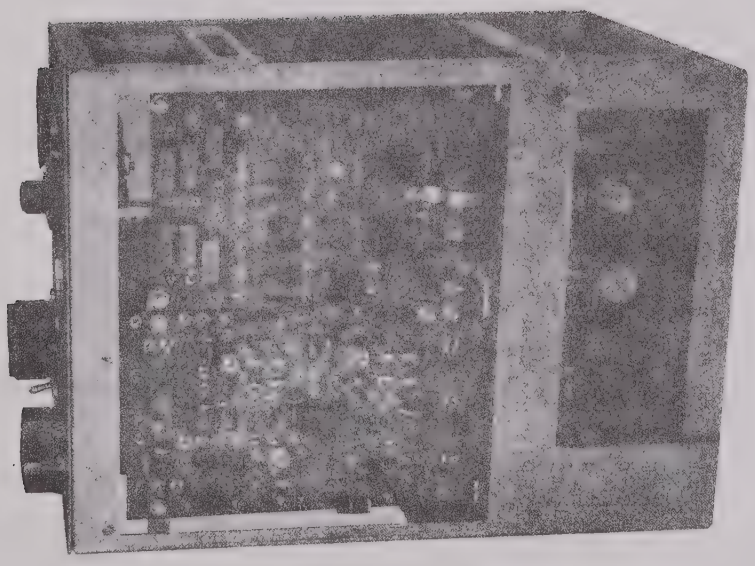
MODEL QR36 - 15A
TOP VIEW



MODEL QR36 - 15A
BOTTOM VIEW



MODEL QR36-4AP
RIGHT SIDE OF CHASSIS



MODEL QR36-4AP
LEFT SIDE OF CHASSIS

NOTES

FIELD SERVICE REPRESENTATIVES

EASTERN AREA

Ampower Electronic Instrument Co., Inc.
26 Just Road
Fairfield, New Jersey 07006
Tel: (201)227-7720

Applied Metrology Inc.
10067 N. 2nd Street
Laurel, Maryland 20810
Tel: (301)953-1010

B & C Instruments, Inc.
7920 Unit 5, Charlotte Drive
Huntsville, Alabama 35802
Tel: (205)883-6530

Valley Instrument Company
491 Clover Mill Road
Exton, Pennsylvania 19341
Tel: (215)363-2650

MIDWESTERN AREA

Certified Test Equipment Sales, Inc.
601 Easy Street
Garland, Texas 75042
Tel: (214)494-3446

Chris-Tec
5366 Kimberly Road
P. O. Box 1010
Minnetonka, Minnesota 55343
Tel: (612)934-1334

Comtel Instrument Company
5827 Mayfield Road
Cleveland, Ohio 44124
Tel: (216)442-8080

Comtel Standards Laboratory
21223 Hilltop Street
P. O. Box 5034
Southfield, Michigan 48037
Tel: (313)358-2500

Rockford Instrument Lab
1718 Broadway
Rockford, Illinois 61108
Tel: (815)397-1004

WESTERN AREA

General Electric Instrumentation Service
3840 W. Clarendon Street
Phoenix, Arizona 85019
Tel: (602)278-8515

General Electric Instrumentation Service
1401 East Valencia Road
Tucson, Arizona 85706
Tel: (602)294-3139

General Electric Company
Instrumentation and Communication Equip. Service
4900 Kingston Street
Denver, Colorado 80239
Tel: (303)320-3250

WESTERN AREA (Cont'd)

J. D. & Associates
1012 Morse Avenue
Suite 6
Sunnyvale, California 94086
Tel: (408)734-5529

Instrument Service Laboratories
630 Haines Avenue N. W.
Albuquerque, New Mexico 87102
Tel: (505)842-1107

Staus Engineering
Unit 26
1900 Tyler Avenue
South El Monte, California 91733
Tel: (213)442-3634

XTEK
14824 Northeast 31st Circle
Redmond, Washington 98052
Tel: (206)885-6969

NEW ENGLAND AREA

Sorensen Company
676 Island Pond Road
Manchester, N. H. 03103
Tel: (603)668-4500

FOREIGN AREA

CANADA

Brunelle Instrument Company
826 Belvedere Street
Sherbrooke, P. Q., Canada J1H4B8
Tel: (819)569-1408

ENGLAND

Cossor Electronics Ltd.
The Pinnacles, Harlow
Essex CM19 5BB England
Tel: Harlow (0279)26862

SWITZERLAND

Sorensen AG
Halbartenstrasse 54
CH 5430 Wettingen
Switzerland
Tel: (056 2651 16)

ISRAEL

Agentex Ltd.
13 Hankin Street
Tel-Aviv, Israel
Tel: (454-151)

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